AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently amended) A quantum communication apparatus, comprising:

n numbers of ensembles denoted as A(i), where ~~(i=1,~~ i = 1, 2, 3, ..., n, n being 2^r, ~~where~~ and r is an integer of 2 or ~~more)~~ more, each ensemble comprising a plurality of physical systems~~, one of the plurality of physical systems~~ comprising:

at least one physical system having at least three energy levels of a first level, a second level and a third level ~~viewed from the lower level~~ in ascending order, in which an angular frequency corresponding to an energy difference between the first and second levels is denoted as ω_{12}[[,]];

a physical system in a state of the first level capable of generating a first photon of an angular frequency ω_1-ω_{12} when irradiated with coherent pulsed light of an angular frequency ω_1 having a first detuning with respect to a transition between the first level and the third level;

and a physical system in a state of the second level capable of generating a second photon of an angular frequency ω_2+ω_{12} when irradiated with coherent pulsed light of an angular frequency ω_2 having a second detuning with respect to a transition between the second level and the third level, where the first detuning is larger than the second detuning;

an optical system for the ensemble A(1), comprising:

an optical shutter S1(1) disposed in an optical path for pulsed light to A(1); and an optical filter F1(1), disposed in an optical path for a photon generated from A(1), which selectively transmits the first photon;

an optical system for the ensemble A(n), comprising:

an optical shutter S1(n) disposed in an optical path for pulsed light to A(n); and

an optical filter F1(n), disposed in an optical path for a photon generated from A(n), which selectively transmits the first photon;

an optical system for the ensemble A(j), where [[(j]] j = 2, 3, 4, ... , ~~n-1)~~ n-1 comprising: an optical shutter S1(j) disposed in an optical path for pulsed light to A(j); a polarization beam splitter T(j), disposed in an optical path for a photon generated from A(j), which is set to a direction to transmit the first photon and the second photon; a polarizer P1(j), disposed in an optical path for the photon transmitted through the polarization beam splitter T(j), which transmits the first and second photons in which a polarization direction of the second photon is rotated; an optical filter F1(j), disposed in an optical path for the photon transmitted through the polarizer P1(j), which transmits the first photon and reflects the second photon; a polarizer P2(j), disposed in an optical path for the photon transmitted through the optical filter F1(j), which adjusts polarization of the first photon; and an optical filter F2(j), disposed in an optical path, branched from the polarization beam splitter T(j), for the photon reflected by the optical filter F1(j), re-transmitted through the polarizer P1(j), and reflected by the polarization beam splitter T(j) to the branched optical path, which selectively transmits the second photon;

a control circuit configured to selectively open optical shutters corresponding to a particular set of ensembles to be irradiated with pulsed light;

beam splitters B1(k), where [[(k)]] k = 1, 2, 3, ..., ~~n/2)~~ n/2 configured to superpose the photon generated from the ensemble A(2xk-1) and transmitted through the optical filter F(2xk-1), and the photon generated from the ensemble A(2xk) and transmitted through the optical filter F(2xk);

pairs of photon detectors D1(2xk-1) and D1(2xk) detecting a photon output from the beam splitter B1(k) in two directions, respectively;

beam splitters B2(l) (l = 1, 2, 3, ..., (n/2)-1) configured to superpose the second photon generated from the ensemble A(2xl), transmitted through the polarization beam splitter T(2xl), transmitted through the polarizer P1(2xl), reflected by the optical filter F1(2xl), re-transmitted through the polarizer P1(2xl), reflected by the polarization beam splitter T(2xl) to a branched optical path and transmitted through the optical filter F1(2xl), the second photon generated from the ensemble A(2xl+1), transmitted through the polarization beam splitter T(2xl+1), transmitted through the polarizer P1(2xl+1), reflected by the optical filter F1(2xl+1), re-transmitted through the polarizer P1(2xl+1), reflected by the polarization beam splitter T(2xl+1) to a branched optical path and transmitted through the optical filter F1(2xl+1);

pairs of photon detectors D1(2xl) and D1(2xl+1) detecting a photon output from the beam splitter B2(l) in two directions, respectively; and

signal processing circuits connected to the respective pairs of photon detectors and configured to generate signals to close the two optical shutters corresponding to the

two ensembles participated in photon detection with either one of a particular pair of photon detectors.

2. (Original) The apparatus according to claim 1, wherein optical transitions between the first level and the third level and between the second level and the third level are allowed, and an optical transition between the first level and the second level is substantially forbidden.

3. (Currently amended) The apparatus according to claim 1, further comprising two light sources [[of]] <u>including</u> a first light source for emitting coherent pulsed light of the angular frequency ω_1 and a second light source for emitting coherent pulsed light of the angular frequency ω_2.

4. (Original) The apparatus according to claim 1, further comprising a single light source for emitting coherent pulsed light of an angular frequency ω_3, the angular frequency ω_3 being used as the coherent pulsed light of the angular frequency ω_1 and the coherent pulsed light of the angular frequency ω_2.

5. (Currently amended) The apparatus according to claim 1, further comprising beam splitters corresponding to the respective optical shutters between [[the]] <u>a</u> single light source and the respective optical shutters.

6. (Original) The apparatus according to claim 1, wherein at least part of the optical paths through is formed of an optical fiber.

7. (Original) The apparatus according to claim 1, wherein the optical shutter is selected from an electro-optical device and acousto-optical device.

8. (Original) The apparatus according to claim 1, wherein the physical system ensemble is an ensemble of rare-earth ions dispersed in a solid material.

9. (Original) The apparatus according to claim 1, wherein the physical system ensemble is an ensemble of rare-earth ions dispersed in an optical fiber.

10. (Original) The apparatus according to claim 1, wherein the physical system ensemble is an ensemble of gas molecules held in a closed space.

11. (Original) The apparatus according to claim 1, wherein the physical system ensemble is placed in an optical resonator.

12. (Currently amended) A quantum communication method using the apparatus according to claim 1, comprising:

preparing the physical systems of the ensembles A(i) in the first level;

performing a first stage operation to generate entanglement between adjacent two ensembles A(2×k-1) and A(2×k), the first stage operation comprising:

opening all the optical shutters S1(i) and irradiating all the ensembles A(i) with coherent pulsed light of the angular frequency ω_1;

superposing, at the beam splitter B1(k), the first photon generated from the ensemble A(2×k-1) and transmitted through the optical filter F1(2×k-1), and the first photon generated from the ensemble A(2×k) and transmitted through the optical filter F1(2×k); and

closing the optical shutters S1(2×k-1) and S1(2×k) when either one of the paired photon detectors D1(2×k-1) and D1(2×k) detects a photon output from the beam splitter B1(k) in the two directions such that all the optical shutters which have been opened are closed;

performing a second stage operation to generate entanglement between two ensembles on the both ends of a set of adjacent four ensembles, the second stage operation comprising:

opening the optical shutters S1(4×m-2) and S1(4×m-1), where ~~(m=1,~~ m = 1, 2, 3, ..., ~~n/4)~~ n/4 and irradiating the ensembles A(4×m-2) and A(4×m-1) with coherent pulsed light of the angular frequency ω_2;

superposing, at the beam splitter B2(2×m-1), the second photon generated from the ensemble A(4×m-2), transmitted through the polarization beam splitter T(4×m-2), transmitted through the polarizer P1(4×m-2), reflected by the optical filter F1(4×m-2), re-transmitted through the polarizer P1(4×m-2), reflected by the polarization beam

splitter T(4×m-2) to a branched optical path and transmitted through the optical filter F1(4×m-2), and the second photon generated from the ensemble A(4×m-1), transmitted through the polarization beam splitter T(4×m-1), transmitted through the polarizer P1(4×m-1), reflected by the optical filter F1(4×m-1), re-transmitted through the polarizer P1(4×m-1), reflected by the polarization beam splitter T(4×m-1) to a branched optical path and transmitted through the optical filter F1(4×m-1); and

closing the optical shutters S1(4×m-2) and S1(4×m-1) when either one of the paired photon detectors D1(4×m-2) and D1(4×m-2) detects a photon output from the beam splitter B2(2×m-1) in the two directions such that all the optical shutters which have been opened are closed;

performing a q-th stage operation, where q is an integer from 3 to r, to generate entanglement between two ensembles on the both ends of a set of adjacent ensembles twice the previous stage, the q-th stage operation comprising:

opening the optical shutters S1($2^q \times m_q - 2^{q-1}$) and S1($2^q \times m_q - 2^{q-1}+1$), where ~~($m_q$~~ m_q = 1, 2, 3, ..., [[n/2^q)]] n/2^q and irradiating the ensembles A($2^q \times m_q - 2^{q-1}$) and A($2^q \times m_q - 2^{q-1}+1$) with coherent pulsed light of the angular frequency ω_2; and

closing the optical shutters S1($2^q \times m_q - 2^{q-1}$) and S1($2^q \times m_q - 2^{q-1}+1$) when either one of the paired photon detectors D2($2^q \times m_q - 2^{q-1}$) and D2($2^q \times m_q - 2^{q-1}+1$) detects a photon such that all the optical shutters which have been opened are closed; and

repeatedly performing later stage operations from a (q+1)-th stage to a r stage ($r=\log_2 n$) corresponding to the q-th stage operation to generate entanglement between two ensembles A(1) and A(n) on the both ends of all the ensembles.

13. (Original) The method according to claim 12, wherein coherent pulsed light of an angular frequency ω_3 is used as the coherent pulsed light of the angular frequency ω_1 and the coherent pulsed light of the angular frequency ω_2.